METHOD OF MANUFACTURING AN OLED DEVICE WITH A CURVED LIGHT EMITTING SURFACE

FIELD OF THE INVENTION

The present invention relates to OLED devices and, more particularly, to OLED devices having a curved format.

BACKGROUND OF THE INVENTION

Light-emissive devices are well known and used for a wide variety of purposes, including area illumination and the representation of information in displays. Traditionally, these light-emissive devices rely on evacuated glass enclosures within which are special gases, phosphors, or filaments that emit light upon the application of a current or when stimulated with an electron. More recently, solid-state light-emissive devices have created robust, long-lived, and practical displays using, for example, light-emitting diodes, liquid crystal, and plasma technologies.

Light emissive devices are useful in a variety of forms. Traditional forms include bulbs rounded in one or two dimensions, for example incandescent and fluorescent light bulbs. Neon lighting is often linear and is used to create lines of light through three dimensions. Large-format information displays such as cinemas rely upon curved screens to maintain an immersive experience for viewers and to more readily simulate a real-world environment. Hence, conventional light-emissive and display devices are found with a variety of shapes, including flat, curved in one or two dimensions, and linear.

Conventional high-output light-emitting solid-state diodes utilize light emitting diodes, typically point sources mounted into a substrate. Because individual devices are individually mounted, these devices can be mounted onto a variety of substrates with a variety of shapes. However, because these devices utilize a collection of point light sources, they require additional optical devices such as mirrors and lenses for suitable area illumination. When applied to information display, individually mounted light emitting diodes are expensive and only suitable for low-resolution displays.

Flat-panel solid-state information display devices such as liquid crystal, OLED, and plasma display devices provide good resolution. Such devices are typically built upon flat substrates, typically glass or silicon, and encapsulated with glass cover layers to provide desired environmental protection. Such structures are typically very rigid and difficult to employ in a curved configuration. The use of flexible substrates and covers for displays, typically plastic, is also known and there is increased interest in flexible, light-emitting, solid-state displays and area illuminators. Such devices typically rely upon constructing a flexible, flat light-emissive device on a flexible substrate and with a flexible cover, and then bending the device to meet the needs of an application. Typically, problems such as cracking and moisture permeation are encountered in such flexible devices.

Referring to FIG. **2**, a prior-art OLED device includes an organic light-emitting layer **14** disposed between two electrodes **12** and **16**, e.g. a cathode and an anode. The organic electro-luminescent layer **14** emits light upon application of a voltage from a power source **18** across the electrodes. The OLED element typically includes a substrate **10** comprising a material such as glass or plastic and is encapsulated with a cover **20**. It will be understood that the relative locations

of the anode and cathode may be reversed with respect to the substrate. The organic light-emitting layer **14** may include other layers such as electron or hole injection layers as is known in the art. Typically, one of the two electrodes **12** or **16** and either the cover **20** or substrate **10** is transparent to allow emitted light to escape from the OLED device. The other electrode is usually reflective.

In general, glass is employed as the substrate for solid-state displays and many illuminators. The specific properties of glass make it a suitable substrate for carrying electro-conductive layers in electric or semiconductor devices such as flat-panel displays, electro-luminescent panels, cathode ray tubes (CRTs), photovoltaic cells, etc. In addition to a high thermal and dimensional stability, glass has many other beneficial properties compared to plastic materials, e.g. the ease of recycling, excellent hardness and scratch resistance, high transparency, good resistance to chemicals such as organic solvents or reactive agents, low permeability of moisture and gases, and a very high glass transition temperature, enabling the use of high-temperature processes for applying an electro-conductive layer. However, the main problems associated with the use of glass as a substrate in electric or semiconductor devices are its high specific weight, brittleness and limited flexibility. The latter problems require the coating of a functional layer on glass to be typically carried out in a batch process (sheet by sheet).

A common alternative to glass for flexible substrates is plastic. Plastic is typically very flexible, shock resistant, and light weight, but is also porous and many light-emitting materials, for example OLEDs are sensitive to environmental contamination that may permeate a plastic substrate. However, the application of layers on a plastic support is generally performed as a continuous process, e.g. by using a web coater or continuous printing techniques such as screen or offset printing, providing improved productivity and cost efficiency.

For some applications, plastic foils may be used as a substrate for carrying electroconductive layers in spite of the many disadvantages compared to glass. The high permeability of oxygen and water through plastic substrates degrades the electroconductive layers rapidly. Some progress has been made on producing plastic foils with barrier layers to limit permeability; however the lifetime of electric devices in which such plastic foils are used is still limited and needs to be improved. In addition, an inorganic conducting layer such as indium-tin oxide (ITO) is brittle and as a result, the electroconductivity of an ITO layer is susceptible to deterioration by simply bending a flexible plastic substrate. All these effects limit the lifetime of such flexible plastic substrate based devices considerably. Other problems associated with plastic substrates include inorganic electroconductive layers such as ITO may require an annealing step at an elevated temperature which is not compatible with most plastics.

A variety of solutions are proposed to overcome the problems and provide some of the advantages recited above. For example, U.S. Pat. No. 6,197,418 entitled "Electroconductive glass laminate" discloses a material that comprises a substrate and an organic electroconductive layer provided on said substrate, characterized in that the substrate is a laminate comprising a glass layer and a support. The glass layer is preferably a flexible glass layer having a thickness from 10 to 500 μm. The material can be used as an electrode in electric or semiconductor devices thereby providing an improved lifetime, e.g. displays, photovoltaic cells or light-emitting diodes. US20030062830 entitled "Reinforcement of glass substrates in flexible devices" describes a reinforce-